Annual Subscription Price, $3. 90 *Published Ten Times a Year.*

The works of the Lord are great, sought out of all them that have pleasure therein.—Ps. cxi, 2.

THE SIDEREAL MESSENGER.

DECEMBER, 1890.

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WM. W. PAYNE, EDITOR,

DIRECTOR OF CARLETON COLLEGE OBSERVATORY.

NORTHFIELD, MINN.

Entered at the Post Office at Northfield, Minn., for transmission through the mail at second class rates.

THE SIDEREAL MESSENGER,

CONDUCTED BY WM. W. PAYNE.

DIRECTOR OF CARLETON COLLEGE OBSERVATORY, NORTHFIELD, MINN.

VOL. 9, NO. 10. DECEMBER, 1890. WHOLE NO. 90

ON THE PROPER USE OF A HANGING LEVEL ATTACHED TO A PORTABLE TRANSIT.

T. H. SAFFORD.

For THE MESSENGER.

It is now thought, by the best instrument makers, that a portable transit should have a reversing apparatus and a hanging level. The two features (in connection) fully make up for their weight and complexity by the smaller dimensions which can be given the whole instrument without sacrifice of accuracy; so that, as I have had occasion to notice, a small instrument thus constructed gives more accurate results than a larger one made with less intelligence.

But the hanging level should never be reversed by hand while astronomical observations are going on. The striding level, or any level, loses greatly in effectiveness when it is much handled; the change of temperature caused by the contact with the hands, and the slight jar which it receives when it is set down, are enough to alter the zero-point; and the results of experience show that this changes quite slowly and continuously when the level is undisturbed.

If, on the other hand, the reversing apparatus performs its work perfectly it will let the level down, along with the pivots, far more easily and smoothly than can be accomplished by the observer's hands; at any rate as carefully as the instrument itself is set down.

Professor Döllen, of Pulcova, a very thorough investigator of portable instruments (he has trained in their use many Russian geographers) has studied this question with great care. His paper, published in 1874, seems to be very scarce; I have tried in fact without success to buy it, and will therefore give an abstract of its results, so far as they relate to the use of the level, from a borrowed copy. He made

an extensive series of levelings both ways; first by reversing the level between the two readings of each pair, and lifting it between the pairs; and secondly by reversing the instrument (level and all) with the apparatus between the two readings of each pair and reversing the level on the pivots only *once* for about 30 readings.

By the first method he obtains directly the difference of level of the *tops* of the two pivots, as astronomers most commonly do. By the second method the pivots themselves are joined with the legs of the level, and the direct result is the difference of level of the points on the Ys where the pivots rest, or that of the *bottoms* of the pivots.

In the first case the difference (if any) of the diameters of the pivots appears in the differences of level, but not in the zero-points of the level itself, for the latter values are independent of the absolute difference of level of the points where the level is supported. In the second case there is no difference of level of the instrument caused by the reversal, for the frame is fixed, and the points determined are on the frame. But as the level goes with the pivots, any difference between these would be added to any difference in length of the arms (or legs) of the level and so affect its zero-points. In order to eliminate this the level may be reversed by hand on the pivots, but from time to time only, and with great care; and never in connection with astronomical observations.

When, for instance, arrangements have been made for a telegraphic longitude compaign, it is very wasteful of labor to combine any needless investigation of the instrument with the evening's work upon the stars. The difference of diameter of the pivots can be determined on any half-hour of a rainy day, and with a good level and good reversing apparatus, almost by any student and certainly by anybody fit to be a recorder. And this determination can be repeated half a dozen times while other preparations are going on. But, with a known difference of pivots, any reversal of the instrument gives an accurate level-zero; and it is a very simple thing to reverse the instrument and determine this zero even while one is waiting for star work to begin or for a telegraph operator to make himself heard at the other station.

But, while the stars are passing, it is an additional needless strain upon the nerves to reverse the level by hand. It is illogical, as one great reason for using a reversing apparatus at all (with a light instrument) is to reverse the level along with the transit.

The following is a series of observations of the difference of diameter of the pivots of our small portable transit by Wanschaff. It has a 2-inch aperture, a "broken" telescope, a hanging level, and reverses with the help of an eccentric (not a gearing, as in the Russian transits) in a very few seconds. The observations were made on separate days during the last term of 1889-90, mostly in connection with students. The first seven determinations comprised sixteen readings, the last eight each; these latter were given half weight:

Date.	Lamp Pivot Thicker by	
March 27	0″.75	
31	0 .80	
April 22	0 .76	
22	1 .35	(Another observer)
25	1 .14	
May 2	1 .16	
5	1 .04	
June 23	1 .98	Half weight
27	1 .19	"
28	0 .99	"
Mean (wt 8½)	1″.07 ± 0″.067	

Probable error of one determination (wt = 1) ± 0″.19 by series of errors, ± 0″.20 by series of squares.

Now, as the correction to be applied to the observed level is only one-fourth this amount, it will be seen that these ten determinations give the correction:

$$0''.27 \pm 0''.017$$

surely accurate enough.

It is, however, extremely difficult to observe the level as accurately in the night as was done in these daylight observations. Why it is so I do not know; but there are several causes which may affect the matter. First, the daylight work was usually done on cloudy, even rainy, weather. when out door work with instruments was impracticable. Hence the temperature was unusually even, and the shutters being closed, no draughts affected the level. Moreover, as nothing was then to be done except make these pivot measurements, they were very leisurely made and carefully timed.

But, as a result, it is very clear that the trifling difference of pivots, whose effect on one-sided time determination is only $0''.27$ sec.φ (or for Williamstown, after reduction to time, only $0^s.025$) can readily be applied to level-readings when the level and instrument are reversed together, and without any loss of accuracy; so that the observer will gain greatly in peace of mind, if not in anything else, if he keep his hands off his level during a time-determination. But for this he must have a level which does not need to be taken off when the telescope passes the zenith. There are two such constructions; the telescope in the first is straight but the level arms long enough to allow the eye-piece to pass; in the second, as in the Williamstown (and Cambridge) transits the telescope is "broken." Most young observers are apt to hurry; not to lose stars they think important. The Russians, who have nearly perfected the practical astronomy of portable instruments, adopt the opposite course. They make their working lists with extreme care, using a few stars only, and allowing time enough between them for the most deliberate judgment as to every point observed; but in this way the observers' nerves are kept in the quietest and best condition, and the observations are not apt to be unexpectedly and abnormally discrepant.

Let me give a programme made up on these principles. I propose to determine time about $23^h\ 35^m$ of sidereal time, using γ Cephei as a polar, and reversing upon it. I will allow about 12 minutes for it—from $23^h\ 29^m$ to $23^h\ 41^m$—and precede it by two stars, and follow it by two more.

The programme will then be:

$23^h\ 12^m$	Read Level at Zenith.
13	Reverse Instrument.
15	Read Level.
19	υ Pegasi—Read Level.
23	70 Pegasi—Read Level.
27	Set on γ Cephei—Read Level.
29	γ Cephei, 4 wires—Read Level.
34	Reverse Instrument.
35	Set on γ Cephei—Read Level.
37	γ Cephei, 4 wires—Read Level.
47	φ Pegasi—Read Level.
52	ψ Pegasi—Read Level.
56	Read Level at Zenith.
57	Reverse Instrument.
59	Read Level.

or, in all, 48 minutes for six observations; counting the polar in reversed positions as two observations. We have now three reversals of the instrument which certainly take no more time than so many reversals of the level alone; twelve level readings each of which can be accomplished in a few seconds; and there is no need of waiting for the level to settle after reversal during the time observations; the first reversal takes place while the observer is getting his tools into order for work; the second while the polar is passing, and the third while he is closing up or resting at the end of the group.

Now in Döllen's series of levellings, before mentioned, the difference in accuracy of the two methods is altogether in favor of reversing the level with the instrument, and not without. It is true the probable error in either case is very small, so that practically there is but little difference; but two complete levellings or four scale readings, when the instrument is reversed, are full as good as twice as many by the ordinary method; what really is of importance is the saving of time and nervous strength by avoiding the reversals of the level by hand.

I will conclude by adding a brief statement of the views here presented.

1. Every portable transit, large enough to have a reversing apparatus, should have a hanging level.

2. This level should have arms long enough to clear the eye-piece in passing the zenith.

3. It should never be reversed by hand during astronomical observations, but turn always with the instrument.

4. The difference of pivots should be obtained by special operations, with closed shutters, in cloudy and rainy weather.

The title of Döllen's paper to which I have referred is:

"Die Zeitbestimmung vermittelst der tragbaren Durchgangs instrument im Verticale der Polarsterns." St. Petersburg, 1874.

Williams College Observatory, October 29, 1890.

THE RADIANT POINTS OF METEORS.

W. F. DENNING.

FOR THE MESSENGER.

Mr. W. H. S. Monck, in essaying to discuss my catalogue of meteoric radiant points, assumes a position which the extent of his experience does not qualify him to fill. He entirely lacks a practical knowledge of the subject. The result is that his deductions are wrong and his statements misleading. Mr. Monck says that I "seldom if ever, watched through an entire night," whereas, in point of fact, I have made observations during hundreds of entire nights! For this and other misstatements your correspondent has no authority whatever, and I am surprised that his desire for notoriety has so obviously out-weighed his discretion.

Mr. Monck has questioned my conclusions by writing to *Nature*, *The Observatory*, *The English Mechanic*, and has privately published a pamphlet in which his adverse criticism is reiterated. In some of these writings he shifts his position; finds that his ideas cannot be "maintained any longer," and is evidently himself perplexed as to what he does and does not believe. One thing, however, has clearly exercised a paramount influence over him, and that is the desire to give the world the benefit of his opinions on a matter which he has never studied in its practical bearings.

With reference to the shifting radiant point of the Perseids your readers may accept it once and for all, as a fact convincingly proved by adequate observation. I have watched this fine shower at its annual returns since 1867, and the easterly motion of the radiant is one of the most certain features I have ever noticed respecting it. Mr. Booth, an able meteoric observer of Leeds, has partly confirmed my results; and when further observations are accumulated I have the greatest confidence that the peculiarity I discovered in 1877 will be fully verified and universally accepted as one of the demonstrated facts of astronomy.

Mr. Monck in drawing his inferences has simply had the published figures to work upon. He does not appear to have considered the relative strength of the various showers, nor could he know the degree of accuracy of the individual radiant points. And there are many other features which,

though familiar to the observer, and by him given their proper weight, are not apparent in the tabulated results—though such details must aid him materially in discriminating aright, they are yet beyond the cognisance of the mere critic who has nothing but a superficial knowledge which is not much good to him, for the facts are very complicated and easily liable to misconception. It is only a thoroughly practical acquaintance with meteors derived from many years of close observation that can enable a man to arrange and group the radiant points in a satisfactory and reliable manner.

I think Mr. Monck is indiscreet in subjecting observers to harassing attacks. His energy might be better applied. Our observations are effected in the hope that they may be useful in elucidating doubtful points and accelerating in some small way the progress of the science we love. Our chief aim is to make reliable observations, and to interpert them correctly. If Mr. Monck thinks that by picking out a few figures from a mass of careful results he can subvert the deductions of the author of them he is greviously mistaken. He may annoy and embarass observers whose hands are already full of work in the delightful field of observation, but he will never shake their integrity or detract from the value of their discoveries. No observer can object to legitimate criticism as this has a tendency to remove anomalies and sometimes gives effect to observations, but mere quibbling is to be deprecated and can certainly never exert any useful influence.

My meteoric observations must stand or fall according to their merits as determined by future observers. Their value cannot be affected by criticism of the kind applied by Mr. Monck. We need facts not inferences. I hope it is not too much to say that I have the utmost confidence in my results.

BRISTOL, ENGLAND, Oct. 15, 1890.

DR. CHRISTIAN HENRY FREDERICK PETERS.

J. G. PORTER.

FOR THE MESSENGER.

On the morning of July 19th Dr. C. H. F. Peters, director of the Litchfield Observatory of Hamilton College, was

found dead upon the door step of the college building where he lodged. His observing cap was on his head and a half burned cigar in his fingers. It is presumed that he was struck down by apoplexy while on his way to the observatory to commence his nightly work. Thus has passed away at the ripe age of seventy-seven one of the most distinguished of our American astronomers. He was a Dane by birth, but pursued his studies at the University of Berlin, taking his degree there in 1836. The next few years he spent in Italy, taking part in the survey of Mt. Etna and other geodetic and astronomical work. Upon the breaking out of the revolution in 1848 he joined the forces of Garibaldi and was speedily promoted to the rank of Major of Artillery. He was twice severely wounded. After the failure of Garibaldi's movement Dr. Peters was forced into exile and spent some time in Constantinople. A few years later, at the suggestion of U. S. Minister George P. Marsh, he came to this country, and after a brief connection with the Coast Survey and the Dudley Observatory, was called in 1858 to the directorship of the Litchfield Observatory then just established. His great ability and wonderful industry soon gave the Observatory an acknowledged rank among the scientific institutions of the country.

One of the earliest contributions which he made to astronomical knowledge was a series of sun-spot observations extending through about twelve years and thus embracing the whole of one cycle of variation in solar activity. His celestial charts are well known. Besides the twenty already published many more are nearly or quite completed. The zone observations which form the ground work of these charts number over 100,000. It was Dr. Peters' intention to publish a catalogue of these star positions in connection with the charts. Upon the group of minor planets he also expended a vast amount of labor. Forty-eight of these bodies were first discovered by him at the Litchfield Observatory. The investigation of their orbits, by no means a light task, was usually undertaken by the Doctor as a recreation after his more arduous duties. He was often called upon to determine geographical positions. The northern and western boundaries of New York state, as well as many places in the interior, were fixed by him.

In 1869 he was enabled through the liberality of Mr. Litchfield to organize a party to observe the solar eclipse at Des Moines, Iowa, and in 1874 he was appointed chief of the U. S. Transit-of-Venus expedition to New Zealand. The remarkable success of his party was a source of much gratification to him. Upon his return a public reception was tendered him in Utica, which was made the occasion of the presentation of a fine pocket chronometer.

Notwithstanding the almost incredible amount of astronomical work that Dr. Peters, almost single-handed, accomplished during the thirty-two years of his directorship, he was by no means a man of one idea. For wide and accurate knowledge in nearly every field of science, and for general intelligence on the topics of the day, he had few equals. His linguistic attainments were unusually great. Latin and Greek were as familiar to him as his native tongue, and he was at home with nearly all the modern languages of Europe including Turkish and Arabic. The knowledge of this latter language he put to good use, having been engaged for some years prior to his death upon the important task of re-editing Ptolemy's Almagest. During recent trips to Europe, several manuscripts hitherto unknown were discovered by him in the libraries of France and Italy.

In 1887 Dr. Peters was a member of the convention of astronomers assembled in Paris to inaugurate the photographic survey of the heavens, and the high distinction of the decoration of the Legion of Honor was then bestowed upon him by the French Government. For many years he has been a member of the National Academy of Sciences as well as of other learned societies at home and abroad.

Personally Dr. Peters was a man of the highest integrity and honor, courteous in his bearing, kind and generous to all. To those who manifested any desire to understand the subject of astronomy he was a most patient and painstaking instructor. He was never married but possessed a social nature and a certain gentle refinement which made him a favorite in the family circles of College Hill. His death, though sudden, was probably painless, and found him, as he doubtless would have wished, in the midst of his accustomed labors. The world-wide fame which he has justly won is due not to transcendent genius or brilliant

episodes, but to faithful, diligent toil and life-long devotion to his chosen profession. His career of usefulness and honor may well be an encouragement and a stimulus to us who are seeking to follow him up the ever ascending pathway of science.

HOW TO MEASURE THE INVISIBLE.*

HENRY M. PARKHURST.

Continued from page 413.

The general laws of optics are most readily understood when light is conceived of as an emanation of particles. But investigation has shown that this is not its true nature. It really consists of vibrations, or waves, or modulations; and it is necessary to take that view of it in order to understand the phenomena I am about to explain.

Waves of light consist of alternate condensation and rarefaction of the ether. It is stated in the books that the different kinds of light move with the same velocity, but that the wave-lengths, or the distances between the points of greatest condensation, vary. The shorter the wave-length, the more is the ray affected by a refracting medium. This is a fundamental principle; and I think a few suggestions, founded upon facts within our own observation, will be sufficient to establish the principle that the extreme red and the extreme violet rays of light move with the same velocity.

For convenience I will assume that if there is any difference, the violet rays move more rapidly than the red; since with equal wave-lengths the extreme violet rays would move nearly twice as fast as the extreme red. In a total eclipse of the sun, when the sun emerges from behind the moon, all the rays start from the moon's edge toward the earth at the same instant. If the violet rays moved most rapidly, they would reach the earth first, and the first glimpse of the sun would be an intensely violet streak of light. For the same reason, the last glimpse of the sun before the totality would be an intensely red streak of light. No such difference has been noted. But as the difference is

* A lecture delivered before the astronomical department of the Brooklyn Institute, October 15, and illustrated with lantern views and diagrams.

only for the gain of the violet rays in the distance from the moon to the earth, which the light traverses in little over a second, the time during which the effect would be visible would be but a fraction of a second.

Let us take then an eclipse at a greater distance. When the shadow of the first of Jupiter's satellites falls upon its disk, it takes forty minutes for the light to reach us. If the violet light moved twice as rapidly as the red, there would be red rays still reaching us for twenty minutes after the violet rays had been cut off. During those twenty minutes the shadow would have moved over one-seventh of Jupiter's diameter. There would therefore be a fringe of red light next the shadow and following it, extending across one-seventh of Jupiter's diameter, gradually approaching whiteness. For the same reason there would be a fringe of violet light next the shadow and preceding it, for an equal distance. The fact that no color is observed, proves that if there is any difference in the velocity of the light of the two colors it is exceedingly small. We have still another test, more delicate still, although not resting upon so certain a foundation. If the diminution of the light of Algol arises from the interposition of a dark body, as seems probable, we have the distance between Algol and the earth, in which the different colors pursue their race; so that if during that distance either gained many minutes upon the other, it would become evident by giving to Algol a corresponding tinge during the latter part of the period of its minimum. In some variable stars a red light is seen; but to be produced by this cause it must be supplemented by an equally observable violet light; which has never been seen although carefully looked for. We may consider it demonstrated, therefore, that light of all colors moves with the same velocity.

The analogy between waves of sound and waves of light gives another illustration. If the same principle of more rapid motion for short wave-lengths were applied to music, the high notes would reach us sooner than the low notes; so that in listening to strains of music in the distance, the high notes would reach us a quaver or semiquaver too soon. Carrying it still further, at the distance of a mile the first line of Duke Street, "Lord, when Thou didst ascend on

high," going up the octave, would have its notes all reach us together; and upon going another mile all would be reversed, the high notes coming first, apparently descending the scale as in the tune of Antioch.

The mode of measuring the wave-length of the different colors, and the effect of wave-length upon refrangibility, I cannot well explain without diagrams, and will defer for the present. But there is one other preliminary suggestion I can make now.

The refrangibility of light depends upon its wave-length. When a wave strikes a refracting surface, what determines the degree of the refraction? That wave passes along in its refracted course without waiting for the next wave. Each wave is refracted independently. My explanation is this: The force of light is divided between the different waves emitted within a given time. There being twice as many violet rays, each has but one-half the force of the red light, it is therefore more retarded by the denser medium, and for that reason bent farther from its course. The fact that red light has sufficient force to penetrate the mists of the morning and evening sky, when the violet rays are stopped, indicates the probability of the correctness of this explanation.

The retardation of waves of light by a refracting medium can be illustrated effectively, I will not undertake to say with how much accuracy, by comparing them with a person attempting to cross Brooklyn bridge at a time when it is so crowded that he is compelled to forget good manners and push his way by main force. The more dense the crowd the slower his rate of progress. The stronger he is the faster he can get along. The moment the way is clear he resumes a pace as rapid as before entering upon the bridge. So the waves of light, however much they are retarded in passing through a dense medium, do not lose their progressive force, as if they had been detained by friction, but, as shown by their outward refraction at the second surface of a lens, they pass onward with unabated vigor and speed.

It is an important consideration that the effect of a refracting medium does not depend upon the absolute wave-length, but upon the relative wave-length. We have an illustration of this with reference to the waves of sound, in the whistle of a passing locomotive. As it approaches us

the pitch is a little higher than it would be if stationary, and the moment it has passed, the sound becomes perceptibly lower while it is receding. To return to the bridge illustration, if the crowd is moving in the same direction with ourselves, we can get along much faster than if it is moving in the opposite direction. The fact that we are moving towards a star, does not increase the refrangibility of its waves by shortening their absolute wave-length, or by weakening their force. But it diminishes their relative wave-length, and it diminishes their power of progressing through the obstacle of a dense medium; and thus it diminishes their velocity, and this increases the refrangibility.

If we were to approach the sun with the speed of light, 200,000 miles per second, carrying with us a refracting prism, there would be twice as many waves striking the prism each second, which would make the relative wave length only one-half. The result would be that the extreme red rays, at the line A, would occupy nearly the position of the extreme violet rays, at the line H. If we were to approach the sun at 200 miles per second, the lines would be shifted only $\frac{1}{1000}$ as much, but in the same direction. That is, the line D^1 would nearly coincide with the line D^2. If then we were to find a fixed star in whose spectrum the sodium lines appear, and if upon comparing the position of its spectrum we should find its D^1 line to correspond with the D^2 line of the sodium flame, we should know that we were approaching that star, or it was approaching us at the rate of about 200 miles per second.

Here we reach the measurement of the invisible without making it visible; for there is no magnifying power which will enable us to see the motion of a star from or towards the earth. The only way it can become visible is by the enlargement of its disk when approaching us; and in the case of a star too distant to have a disk, of course this would be imperceptible.

This method has been applied to many stars, with varying results, indicating motions relatively to the earth, sometimes towards and sometimes away from us.

This method was recently applied to the star Algol, by Vogel. He measured the positions of the lines at different periods with reference to its minimum phase, and found that

before the minimum Algol was receding from us, and that after the minimum Algol was approaching us. He repeated these observations often enough to make it certain that the change of its motion was connected with its apparent brightness. Although he could not see any companion, it was evident that there must have been a dark companion with similar and opposite motion, the two revolving about a common center. He deduced certain results with regard to the masses of the two stars thus connected with each other; but there seems to have been introduced as a link in the chain of reasoning, more or less conjecture. I prefer, therefore, to pass on at once to another more remarkable discovery of the same character, which was made at about the same time by Professor Pickering at Harvard.

In photographs of Mizar, showing its spectrum, it was observed that some of the darker lines appeared double. At other times the same lines appeared single. By taking repeated photographs there was found to be a periodicity about this duplication of the lines, so that it could be predicted. What was the cause of it? Manifestly that the star Mizar, never seen optically as double in the most powerful telescopes, nevertheless is a binary star, the two components revolving around a common center of gravity in twice the period of the duplication of the lines. For calling the two stars A and B, when A is approaching and B receding, their lines will be separated by the difference of their relative motion; when A is nearest and B the most distant, neither will have any motion to or from the earth, and the lines will coalesce; then A recedes and B approaches, the lines again separating but being transposed from their former position; and finally A will be most distant and B the nearest, when the lines will a second time have coalesced. Since the duplication occurred every 52 days, it is manifest that the period of revolution is 104 days.

It will be noticed that the distance of Mizar from the earth has no relation to this duplication of the lines; it depends wholly upon the rate of motion of the two bodies, A and B, as compared with the wave lengths of the undulations of light. Were Mizar a million times, or millions of millions of times as far away as it actually is, the separation of the lines would be the same; all the difference would

be that being more distant the star would be fainter, and being fainter its spectrum could not be so easily seen. Were our sun to be gradually removed from Mizar, the lines would grow fainter and fainter until they disappeared, but the amount of their separation would remain uniform. Nor does the distance of the stars A and B from each other at all affect the separation of the lines. Were they a million times as far apart, moving with the same velocity, the separation would remain the same; or were they a million times as near together, moving with the same velocity, the separation would remain the same.

The first thing ascertained from these observations was the period of revolution. Next we have the actual rate of motion. The relative motion causing the division of the lines, is the sum of the motion of the two bodies. The two lines appeared equal in blackness, showing that the two stars are nearly equal in brightness; from which it may be inferred that they are nearly equal in mass. If so, the indicated motion of 100 miles per second is twice the actual motion of revolution. But as, by the laws of motion it makes no difference in what proportion the mass is divided between the two bodies, it will be most convenient to speak of one of the stars as stationary and the other in motion. We may now determine the size of the orbit; for if the motion is 100 miles per second in a circular orbit, and if it requires 104 days of such motion to complete the orbit, the circumference of the orbit must be about 900,000,000 miles and the distance of the two stars about 143,000,000 miles. This is but two million miles greater than the distance of the planet Mars from the sun, whose period is 687 days. As its actual motion is more than six times as rapid, revolving through the same distance in 104 days, the mass must be increased, to preserve a circular orbit, by the square of this ratio; showing that the mass of the two stars is about 40 times the mass of our sun.

A few additional and new computations, based upon the most available assumption of brilliancy, may be interesting. Dividing this mass between two stars of equal density with our sun, and of equal brightness of disk they would give about 15 times as much light. Adopting Sir John Herschell's estimate of the comparatvie brightness, that would

correspond to a distance from us 9,000,000 times greater than that of the sun. This would correspond with a parallax of one-forty-fifth of a second and a distance which would require nearly 150 years for light to travel. In miles, the distance would be 830 millions of millions of miles. The distance of the two stars optically would be one-thirtieth of a second, far beyond the reach of Burnham with any telescope he will ever live to look through.

We have therefore the elements of the orbit thus determined, the distance apart of the two stars, the period and the masses. These elements are only approximate, however, for we have assumed the plane of the orbit to pass nearly through the earth. If the plane were at right angles with the line joining the star and the earth, there would be no relative motion of approach or recession, and no separation of the lines. Another star of equal brightness might be composed of two stars of the same size revolving in precisely the same manner, excepting that the plane of the orbit should be at right angles to us, and we could never by this method discover its duplicity.

Suppose that the orbit is between these two positions. Suppose that it is at an angle of sixty degrees with the line of sight. In that case the actual relative motion would be twice as great as the apparent relative motion. The actual distance of the two bodies from each other would be twice as great as our calculations would show; and the combined masses would be four times as great to preserve circular motion at this increased distance.

We have assumed circular motion. It would require a very considerable variation from a circular orbit to make itself apparent, or to materially affect our results. With an orbit as excentric as some of the asteroids, the motion would be a little faster at a given distance with a given mass; so that a little less mass would be required than for a circular orbit. But the difference would be very much less than the uncertainty in the determination of the exact separation of the lines, and very much less than the uncertainty in the position of the orbit. Indeed it is manifest that if the plane of the orbit were very nearly at right angles with the line of sight and yet the relative apparent motion sufficient to produce an appreciable separation of the lines, our com-

putations by the above described method would be widely in error. On the other hand there might be a considerable deviation of the plane from coincidence with the line of sight, without materially affecting the computations; and the chances are strongly in favor of the supposition that the main element of uncertainty is the exact determination of the amount of the separation of the lines. If such discoveries should be many times repeated, including many fainter stars, it would then become probable that among them all, there would be one or more to which our mode of computation would not accurately apply. The question would then arise for science to devise some new test to meet this emergency. And difficult as is the problem, we may reasonably expect success.

AN EXAMINATION OF THE PLACE OF TYCHO BRAHE'S STAR.

S. W. BURNHAM.

For The Messenger.

Having some observations to make in Cassiopeiæ, near the observed place of the celebrated temporary star of 1572, known as Tycho Brahe's star, I took occasion to examine, with the 36-inch telescope, the region about the point given by D'Arrest as the most probable place of this star. Of course it was not so much in the hope of finding anything new which could be connected with what is known in the newspapers as the "Star of Bethlehem," as to see whether any new discovery of interest could be made with the large telescope in that vicinity. The particular point assigned by D'Arrest for this star is not closely marked by any stars bright enough to be included in Argelander's Catalogue, but there are several of about the ninth magnitude within a radius of 15′ or 20′. D'Arrest has given a diagram of all the faint stars down to 16 magnitude covered by a space of $4\frac{1}{2}^{m}$ of right ascension by 50′ of declination. I did not undertake to ascertain how many more could be seen with this instrument, but presumably the number would be largely increased. None of these faint stars presented any peculiar appearance worth noting. The brighter adjacent stars were then examined, and one of the nearest of the Argelander

stars, D. M. (63°) 48, was found to be a close double. The mean of three nights' measures gives

$$P = 31°.9 \quad D = 0''.52 \quad \text{Mags. } 9.2, 9.3 \quad 1890.74$$

This is 2^m following and 18′ north of the assigned place of the Tycho Brahe star. It would probably be very difficult with a moderate aperture, if not beyond its reach altogether. The place of this star for 1880 is:

R. A. $0^h\ 19^m\ 57^s.7$
Decl. 63° 46′ 2″

About 8′ north and a little following is a 12″ pair of 9–10 magnitude stars.

Another star differing but little in declination from D'Arrest's place, but further following in R. A. was found with the 12-inch to be an unequal double. The measures with the 36-inch on three nights give

$$P = 90°.2 \quad D = 1''.66 \quad \text{Mags. } 8.4, 11.3 \quad 1890.74$$

This is D. M. (63°) 52, and is rated 8 mag. by Argelander. In the future these stars may prove to be of some interest.

OUR KNOWLEDGE OF MARS.

JOHN RITCHIE, Jr.

The planet Mars, during the few years past, has received considerable attention from journalists and writers, who have discussed it with that tendency towards the sensational which is so characteristic of these days. A plain statement, therefore, of our present knowledge, drawn, as much as may be, from the writings of the observers themselves, will not be out of place. While it is to be regretted that absolute conclusions cannot be deduced from our known facts, this failure is of no great moment, for it is better to know a little and know it well, than to know a great deal, and have it not true.

The planet Mars is our neighbor in space, and presents such analogies to our own conditions as to be of great interest to us. In size it is inferior to the earth; in climate not widely different; and it is by no means impossible that

life on Mars may have reached the perfection which it enjoys here. Its time of revolution about the sun is two years, and its distance as compared with that of the earth about as three to two. At conjunction its disk measures about four seconds of arc, while at opposition it is sometimes as large as thirty seconds, hence it is more easily observed at these times.

White spots were possibly indicated on drawings of Mars made in the seventeenth century, and early in the eighteenth they were positively shown. Two of these spots have remained with constancy, and have been termed the snowy poles, which are generally considered analogous to our own poles. Since the map of Mädler, in 1830, drawings of Mars have been made, until many hundreds are in existence, and if due dependence could be placed in the accuracy of the representations, much information might be deduced.

Observers have noted changes in the physical aspect of the planet. Some of these—the slow variation of the polar caps, for instance—are relatively easy to follow. Others are even more rapid, being accomplished in a few days, while other effects are different from one day to another. Among the last class is the so-called "doubling" of the canals. Finally, other changes are found to coincide in time with the period of revolution. Many difficulties lie in the way of an accurate and complete study of these changes. Observations are limited to certain hours of the day, and also to that period of four months when Mars is near opposition. The oppositions occur in different parts of its orbit and under varying inclinations of its axis, so that at least sixteen years is necessary for the complete inspection of the planet. In addition, there are our conditions of atmosphere, and finally the difficulty in comparing the observations made by different men with different telescopes on account of instrumental and personal peculiarities.

Upon certain differences in color rests the notation "continent," "sea," "canal," "island," etc. This notation must be regarded only as a matter of convenience, and positively does not imply anything with reference to the physical condition of the surface. Some regions, usually of small area, are sometimes seas, sometimes continents. In the light of this statement, it is interesting to note M. Flammarion's

position in a paper in the *Comptes Rendus* in 1873. This summed up the known facts at that date. Briefly his statements are:—the polar regions are covered with snow, there are clouds and atmospheric currents, the atmosphere being more saturated in Winter than in Summer, the surface is quite evenly divided into land and sea, the meteorology is similar to ours, water exists in the same state physically and chemically, the continents are covered with forests of a reddish hue, and the conditions for life are little different from those of the earth. With the sanguineness and ardor of his nation he made at this time a series of claims, which, seventeen years later, with whatever has been added to scientific knowledge in the interim, cannot be considered as at all well proven in many respects.

The canals are an interesting feature of the surface of Mars. Much of the information concerning them is from the Italian observer Schiaparelli, a good, careful, accurate and reliable astronomer. These canals, according to him, cover with a network all of the continental region. They form usually an arc of a great circle, some of great length, as much as ninety degrees, and vary greatly among themselves in breadth. Their visibility, breadth and form vary from one opposition to another, and even during the course of a week. These changes are not simultaneous, but partly local, so that a map must be regarded rather as a topographical index than as a representation of the actual appearance. Every canal ends in a sea or another canal—an important feature of an unknown import. Schiaparelli characterizes the physical circumstances connected with the canals as follows: A canal may be invisible for a longer or shorter time, it may be obscured by the variation of the color of the adjoining surface, the type is dark in color, but sometimes is like a faint gray stripe, and canals vary greatly in width.

During the opposition of 1881-2, Schiaparelli made some discoveries which have excited much discussion. During fifty consecutive nights, sixteen perfect and fourteen exceedingly fine (in Italy), these observations were made. The chart which accompanies his paper to the Society of Italian Spectroscopists is suggestive of a double printed photograph. His discovery, as he states it, was that a canal

would, in a few days, sometimes a few hours, appear as if composed of two parallel stripes, one of which, usually, occupied the true space of the canal. The relation of the stripes to the place between them varied in different canals, the color of both stripes was the same, and all irregularities, if present in the single canal, disappeared on "doubling." Sometimes at the intersection of two canals the duplication would stop, and the same canal would be both single and double in different parts. Schiaparelli observed these features in wonderful detail and was even able to follow the process of "doubling" in one or two instances. In 1886, Perrotin of Nice consideered that his observations strongly confirmed those of Schiaparelli. During the opposition of 1888 Mars was much observed. Perrotin notes that part of the canals seen by him two years before, in the same places and of the same character, some simple, others double. He signalizes some marked changes, the disappearance of a continent, Lybia, (about as large as France), and of a lake, and the appearance of a canal across the north polar cap.

Unfortunately for the observer at Nice, Niesten of the Observatory of Brussels had made drawings of Mars at an interval of six days, during which interval Perrotin took his observation. The continent which he declares *complement disparu* appears on both of the Belgian drawings. Although with French politeness M. Niesten explains how the continent might have suddenly reappeared, the inference is obvious, and as an observer of Mars, confidence in Perrotin has sustained a shock—and unfortunately, since he has been so strong a supporter of Schiaparelli. Niesten goes on to state that he has not been able to see the duplicated canals, although some can be seen single while others resemble the boundary lines of two different tints of the planet's surface.

Coming nearer home, Prof. A. Hall, of Washington, observed Mars carefully with the great refractor of the Naval Observatory at Washington, on eighteen nights in 1888, but failed to see the regular canals of the European observers. Prof. E. S. Holden, of the Lick Observatory, states in the Astronomical Journal that, while the most favorable time for observation had passed before the Lick telescope could be used, still he secured a fair series of results. With regard to the canals, he failed to see any "doubling." Lybia was

frequently drawn here during the period of its disappearance from France.

Various theories to account for the existence of the canals have been suggested. The notion that they can be the work of inhabitants fails on account of the enormous size of these lines, sometimes a thousand miles long and fifty broad. Fitzeau's theory of glacial crevasses demands the existence of forces of such magnitude as to be unreasonable from an earthly standpoint, and no hypothesis has been suggested, which can be to-day accepted as reasonable.

The matter rests here, then, in an unsatisfactory condition with regard to the physical phenomena of Mars. On the one hand, we have skillful and competent astronomers asserting the existence of markings, and furnishing drawings containing the most minute details. On the other hand, equally trustworthy authority, with at least equal optical means, confess their inability to see even the most prominent features of the objects whose existence is in dispute. The weight of judgment among astronomers inclines to skepticism on the subject, but in either event we must wait patiently until further observations shall establish or disprove the truth of the alleged discoveries.—*Boston Commonwealth, Oct. 18, 1890.*

STATIONARY OR LONG-ENDURING METEOR-RADIANTS.

W. H. S. MONCK.

FOR THE MESSENGER.

In my article on Stationary Meteor-Radiants, which appeared in your October number, I find I was inaccurate in describing the fire-ball whose period was computed at 462 days as an Andromede. Though agreeing in date with the Andromede shower and bearing some other points of resemblance it was, I find, referred to a different radiant.

I have also been informed that my assumption that the vessel would carry the balls with it in its motion is erroneous. I only referred to the balls as an illustration of my theory. A better one would probably have been a number of boats or steamers crossing the current. I offered this explanation as far back as the year 1885 (see *The Observa-*

tory for December, 1885 and January, 1886), but stationary radiation was then regarded as an exceptional case whereas I now regard it as the rule if not an invariable law. The explanation however involves difficulties which renders me very doubtful of its validity. My pamphlet (to which you refer in a subsequent note) was only printed for private circulation.

With regard to the supposed cometary showers I may note that though no position very near the Lyrids or Leonid radiants appear in Mr. Denning's list at other times of the year the observations of others go far to supply the deficiency. Moreover the Perseids and Lyrids do not seem to exhibit any periodicity agreeing with that computed for the comet.

It is worthy of remark that, should my theory prove correct, meteor-radiants may be determined by projecting the paths of meteors observed at any time of the year instead of confining our attention to those observed nearly at the same date. A much larger amount of information may thus be derived from observations already collected.

For the convenience of those who may wish to test my statement that when Mr. Denning's Catalogue is arranged in order of R. A. the grouping becomes immediately apparent, I give a list of the radiants for the second quadrant (which I prefer to the first as avoiding the question of shifting radiants) in order of R. A. The numbers are those in Mr. Denning's Catalogue.

R. A. 90° to 180°; Nos. 712, 698, 707, 659, 722, 675, 723, 647, 699, 718, 703, 915, 713, 660, 302, 743, 734, 607, 905, 608, 589, 871, 700, 787, 507, 834, 609, 539, 751, 590, 641, 864, 648, 770, 835, 389, 860, 661, 36, 853, 674, 704, 875, 719, 591, 714, 677, 916, 478, 762, 876, 592, 614, 595, 727, 865, 880, 843, 678, 752, 854, 560, 797, 811, 540, 662, 907, 861, 601, 610, 877, 663, 593, 3, 686, 687, 705, 911, 763, 786, 720, 728, 679, 771, 764, 594, 688, 894, 899, 18, 541, 689, 31, 803, 849, 680, 756, 690, 739, 908, 681, 642, 772, 615, 891, 291, 664, 460, 844, 691, 917, 10, 812, 804, 862, 114, 878, 855, 692, 780, 765, 866, 900, 13, 292, 814, 773, 774, 781, 775, 801, 782, 788, 665, 879, 693, 789, 815, 542, 805, 790, 872, 24, 122, 482, 60, 873, 850, 918, 175, 69, 895, 881, 796, 4, 40, 673, 912, 806, 824, 882, 48, 61, 46, 909, 682, 825, 19.

DUBLIN, Oct. 30, 1890.

BRITISH ASTRONOMICAL ASSOCIATION.

The first general meeting of this Association was held on Friday, the 24th of October, in the Hall of the Society of Arts Adelphi. The chair was taken by W. H. Mead, Esq., temporary treasurer; Mr. E. W. Maunder, temporary secretary, read the report of the provisional committee, giving an account of the formation of the Association up to the date of the election of the Council. The report having been unanimously adopted, the senior scrutinist, Edwin Durkin, Esq., F. R. S., read the certificate of the election of the Council and Mr. W. H. Wesley read the certificate of the election of officers by the Council. The meeting having unanimously confirmed these elections and also the appointments of the directors of sections Captain W. Noble, F. R. A. S., took the chair as president of the Association and the meeting proceeded to the discussion of the rules. After careful consideration, and in order to avoid any posible confusion or misconception between the names of this Society and the Royal Astronomical Society, especially abroad, it was decided to alter the name by substituting the word Association for Society. The hour of five o'clock was fixed upon as the time for the meetings of the Association in the hope that it might be found convenient both by town and country members. The month of June was selected for the annual meeting. Several alterations were made in the draft rules. The meeting closed with votes of thanks to the chairman and the provisional committee.

The first *public* suggestion for the formation of this Society was made by Mr. Monck in a letter to the "English Mechanic" of July 18th of this year, and shortly afterwards Mr. E. W. Maunder undertook the task of ascertaining the views of a number of gentlemen interested in Astronomical research on the subject, his letters in every case containing a suggested programme. The responses were in almost every instance so satisfactory, and the offers of co-operation so numerous that a printed circular embodying the suggested programme, and bearing the names of those gentlemen who had promised assistance was sent out. The issue of this circular and notices in the public press brought an immediate accession of numbers and further offers of support. A

second circular, containing a somewhat fuller programme, and including the additional names of those ladies and gentlemen who had in the meantime consented to serve on a provisional committee, was issued a few days later.

The accessions to the Society proceeded so rapidly that toward the end of August the provisional committee after careful consideration, decided upon the following scheme:

1. That the Council of the Society should consist of,

(*a*) Eight officers, viz: A president, four vice-presidents, treasurer, secretary and editor,

(*b*) Fourteen ordinary members.

(*c*) Eight (or more) directors of sections who should be *ex-officio* members.

2. That for the election of the first Council a list of thirty names selected by the committee from a full list of members should be submitted to a ballot of the Society and that the twenty-two highest names should constitute, together with the directors of sections, the first Conncil.

3. That this Council should elect the officers of the Society, prepare a draft of rules, and call a general meeting at the earliest convenient date.

4. That the general meeting should confirm or otherwise the election of officers and directors of sections and discuss and pass a code of rules.

These resolutions were carried into effect without any delay. Ballot reports were duly issued to every member of the Society, and on Oct. 1st two scrutineers appointed for the purpose, by the committee, Edwin Durkin Esq., F. R. S., and E. E. Baly, Esq., deputy chief cashier of the Bank of England, met and counted the votes. The first meeting of the Council was held on Oct. 8th, and the officers of the Society were elected and a code of rules drafted, and Friday the 24th of October, was fixed upon as the date for the general meeting. A notification to that effect together with a printed copy of the draft rules and a circular containing the names of the members of the Council, the officers of the Society and the directors of sections, was forwarded to each member.

THOMAS F. MAUNDER, Asst. Secretary.
26 Martin's Lane, Cannon Street, London, E. C.

THE CORRECTION OF OBSERVATION DATA BY THE METHOD OF LEAST SQUARES.*

HERBERT WHITAKER.

In observations there are two possible sources of error; first, accidental errors, which are of such a nature that in the long run they are as apt to be positive as negative, thus tending to eliminate each other; and, second, systematic errors which are of the same sign and tend to cumulate. An error in reading a scale is an instance of an accidental error, but an unknown error in the length of a scale used is an instance of a systematic error: for in the long run an observer would be as apt to read a scale too long as too short, but observations with an incorrect instrument of measurement evidently do not tend to eliminate each other, being, on the contrary, cumulative.

Suppose that a mile were measured by a 100-foot chain making 53 measurements necessary, and that the chain pins were misplaced two inches at each measurement and suppose that the chain itself were one inch out. Now it is shown by the theory of probabilities that in accidental errors, the square root of the whole number of errors are probably uneliminated in the total; in this case the total accidental errors due to the setting of the pins would be the square root of 53 times 2 inches or 14 inches; while the total systematic error due to the incorrect length of the chain would be 53 inches, nearly four times as much as that due to accidental error, although each of these last errors was only one-half of the first.

Systematic errors furnish no trace of their presence, even in repeated observations, since they affect all of the observations alike; and the presence of this class of errors in a series of observations constitutes the greatest obstacle to the accurate determination of the values of any quantities sought. They can however be transformed into accidental errors by varying the method of observation. Thus by employing a number of different standards of measurement in the same series of observations the cumulative errors due to an erroneous standard, would be transformed to eliminative errors, since different standards are as likely to be too short as too long.

* A paper read before the Camden Astronomical Society.

In the method of obtaining most probable values of unknowns from observation data, it is of necessity assumed that systematic errors have been eliminated.

Suppose it were desired to determine a general expression for the accelerative force at the surface of the earth, due to the earth's attraction. From theoretical considerations, the form of the expression is known to be

$$g = x - y \cos 2\lambda$$

in which x and y are constants to be determined and λ is the latitude.

Suppose observations to have been made at six different places and the values of g (π^2 times the length of the second's pendulum), and of λ so obtained were substituted in the above equation, giving six equations with two unknown quantities. Such equations are called observation equations, evidently any two of them being sufficient to determine the constants x and y; but if the values obtained from any two of them were substituted in the other four of the observation equations, there will generally be a slight difference in the values of the right and left hand members of each of these equations. These differences have been called residuals and by a course of analysis based upon the theory of probabilities, it has been shown that the most probable values of the unknown quantities are those which make the sum of the squares of their residuals a minimum, and hence the name of Least Squares.

To form the equations filling this condition, everything in each of the observation equations is transposed to one side and, instead of zero, the other side is called e', e'' e''', etc.; thus $g - x + y \cos 2\lambda = e'$. Each equation is now squared and the sum is taken, giving the value which is to be a minimum.

To determine this minimum, the first differential coefficient of the sum of the squares of the equations must be equated to zero and so taking the first differential coefficient of this expression with reference to one of the unknowns, say x, equating to zero and comparing with the observation equations and it is seen that the equation involving the condition that the sum of the squares of the errors shall be a minimum is obtained by multiplying each of the observation equations by the coefficient of x in that equation and taking the sum of

all the equations thus formed. The same process is gone through with for each of the other unknowns; thus for y, multiply each of the observation equations by the coefficients of y in that equation and take the sum of all the equations thus formed. Having operated in this manner for each of the unknowns, there results as many equations as there are unknowns and the roots of these equations furnish the values sought.

If the purpose of the observations were the measurements of a single quantity, such as a length, the form of the observation equation would be $l = x$, and to find the most probable value of x, the sum of the measurements is taken and divided by the number of the measurements since the coefficient of x was one in each equation. But this is the process of finding the arithmetic mean and it thus appears that the practice of taking the average of all the measurements of a quantity as the most probable value of that quantity is a particular case under the method of Least Squares. If the observer feels that on account of circumstances attending the observations, the accuracy of some of them can be depended upon more than others, the equations are weighted as it is called. Thus, if the accuracy of three observations are considered to be in the ratios of 1, 2 and 3, the second observation equation would be repeated twice and the third one three times before being operated on by the usual method.

When a formula is sought, if the causes which are operating are known, the form of the observation equations can usually be determined by mathematical analysis; in other cases such empirical formula as

$$y = a + bx + cx^2 + dx^3 + \text{etc.},$$

and
$$y = a + b \sin \frac{x}{n} + c \sin \frac{2x}{n} + d \sin \frac{3x}{n} + \text{etc.}$$
$$+ b_1 \cos \frac{x}{n} + c_1 \cos \frac{2x}{n} + d_1 \cos \frac{3x}{n} + \text{etc.}$$

could be used.

Camden Astronomical Society. At the regular meetings of the Camden Astronomical Society held during the present year, the following papers have been read: On the probable age of the World, by R. M. I uther, D. D.; A review of Borrelli's "De Vero Telescopii Inventore," by H. H. Furnes, Jr.; On light, by T. Worcester Worrell; On the Date of the Settlement of Ancient Egypt from an Astronomical point of view, by Edward F. Moody; On the Method of Least Squares, by Herbert Whitaker.

CURRENT CELESTIAL PHENOMENA.

THE PLANETS.

Mercury will be visible to the eye on a few evenings in the latter part of December, when he will set in the south west about an hour and a half after sunset. He will be at greatest elongation, east from the sun 19° 38′, Dec. 27; at the ascending node of his orbit Jan. 2; at perihelion Jan. 7, and at inferior conjunction with the sun Jan. 13 at 11^h 31^m A. M. central time.

Venus will be at inferior conjunction Dec. 3 at 10:24 P. M. central time. At that time Venus will be only 36′ south of the sun's center or 20′ from the south limb of the sun. Rev. S. J. Johnson (*Observatory, Nov. 1890, p. 357*) calls attention to the possibility of seeing the thread of light, due to the planet's atmosphere, encircling Venus at the time of this conjunction. In Dec., 1866, when Venus was very near her node at inferior conjunction, and passed unusually near the line from the earth to the sun, Professor Lyman, of Yale College Observatory, was able to see the fine thread of light completely encircling the planet. For southern observers the position of Venus at this conjunction will be very favorable for the observation of this phenomena. In the northern hemisphere the low altitude of the planet is unfavorable, but it may be possible for observers to catch glimpses of the planet on the afternoon of Dec. 3, or the morning of Dec. 4.

The article on Venus by G. V. Schiaparelli is concluded in the November number of *L'Astronomie*. He reaches the conclusion that the rotation of Venus is very slow, the period being probably 224.7 days, or the same as that of its sidereal revolution about the sun, and about an axis very nearly perpendicular to the plane of its orbit. That is to say, Venus always keeps the same side toward the sun, just as the moon does to the earth, and as Mercury also does to the sun.

Mars is moving rapidly eastward through Aquarius. The change in relative position of the two bright planets, Mars and Jupiter, has been very noticeable during the past month. The distance of Mars from the earth is now about one and one-half times the distance of earth from sun, so that its disk is very small and but little detail can be seen upon its surface, under ordinary circumstances. An interesting article by Dr. Terby on the observations of Mars during this opposition is given in *L'Astronomie* for November. The opposition has been an unfavorable one for northern observers, on account of the low altitude of the planet, but a large number of Schiaparelli's "canals" have been identified and several have been seen doubled. Observations by Messrs. A. Stanley Williams, Schiaparelli, Terby and W. H. Pickering are cited.

We have recently had the pleasure of examining two fine drawings of Mars, made during the past summer by Mr. J. E. Keeler with the great Lick telescope, which show several of the canals. But the most noticeable features of one of these drawings were two white projections beyond the terminator of the planet in the northern hemisphere. These seem to indicate the presence of clouds at a considerable elevation in the atmosphere

of Mars. They were so obvious as to be noticed by a visitor who, looking through the great telescope on the regular visitor's night, called attention to their existence.

Jupiter is getting too near the sun to be well observed, but may be seen for about three hours after sunset near the southwest horizon. We have been permitted to examine four very excellent drawings of Jupiter made by Mr. Keeler with the Lick telescope, three of them during the present year. These show a wonderful amount of detail upon the face of the planet. An interesting fact, about which there has been considerable dispute, appears to be shown by these drawings; that is, that the dark markings, which have a shorter period of rotation in the same latitude with the great spot, seem to flow around the latter as they pass by it, just as the water of a stream flows around an island. Mr. Keeler says that it is undoubtedly true that dark markings, on coming up to the red spot, are forced to one side and crowded together, so as to have a denser appearance, and that their latitude is permanently changed. On the other hand, *L'Astronomie* gives an account of an observation made by M. Stuyvaert at Bruxelles August 25, 1890, when the red spot was found to be partially covered by the grey temperate band of the southern hemisphere. This observation was confirmed by Messrs. Niesten and Stuyvaert on August 30, when the same appearance was again noticed. This would indicate that the red spot is at lower level than the dark markings.

Saturn may be observed after midnight. He may be easily found toward the east in the lower part of the constellation Leo, being brighter than any of the stars in that vicinity. Saturn will be at quadrature December 8, and stationary in right ascension December 28. Mr. Marth's ephemerides of the satellites of Saturn for November and December, 1890, have just come to hand in *Monthly Notices*, Vol. L, No. 9. Those for 1891 will be given in the next number of the *Monthly Notices*. We notice that Titan will be in transit across the disk of the planet December 4, inferior conjunction occurring at 9.3^h P. M. central time. Titan will be occulted December 13, superior conjunction 7″ south of Saturn's center, at 3.6^h A. M. There will be a transit of Titan again December 20 at 8.4^h P. M.

Uranus may be seen in the morning after 3^h A. M. He is near the foot of Virgo about 10° directly east from Spica and 2° south west of the third magnitude star κ Virginis.

Neptune may be seen all night. In the early evening he is toward the east. The groups of the Pleiades and the Hyades with the bright red star Aldebaran are easily recognized. Neptune is about one third of the way on a straight line from Aldebaran to the Pleiades. A telescope of considerable power will be needed in order to distinguish this planet by means of its disk.

MERCURY.

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Dec. 25	19 42.0	− 23 04	9 00 A. M.	1 25.0 P. M.	5 50 P. M.
Jan. 4	20 10.2	− 19 34	8 32 "	1 13.9 "	5 56 "
14	19 32.8	− 18 28	7 10 "	11 57.2 A. M.	4 44 "

VENUS.

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
Dec. 25	16 12.7	− 17 14	5 03 A. M.	9 56.2 A. M.	2 49 P. M.
Jan. 4	16 22.6	− 16 50	4 32 "	9 26.8 "	2 21 "
14	16 44.6	− 17 27	4 18 "	9 09.5 "	2 01 "

Date. 1890.	R. A. h m	Decl. ° ′	Rises. h m	Transits. h m	Sets. h m
			MARS.		
Dec. 25	22 34.9	− 9 56	10 54 A. M.	4 17.5 P. M.	9 41 P. M.
Jan. 4	23 02.7	− 6 57	10 30 "	4 05.8 "	9 42 "
14	23 30.0	− 3 52	10 06 "	3 53.7 "	9 42 "
			JUPITER.		
Dec. 25	21 02.6	− 17 39	9 59 A. M.	2 49.3 P. M.	7 40 P. M.
Jan. 4	21 12.1	− 16 58	9 22 "	2 15.5 "	7 10 "
14	21 21.1	− 16 17	8 48 "	1 45.2 "	6 42 "
			SATURN.		
Dec. 25	11 15.9	+ 6 51	10 26 P. M.	4 56.3 A. M.	11 27 A. M.
Jan. 4	11 15.7	+ 6 55	9 46 "	4 16.8 "	10 48 "
14	11 14.9	+ 7 03	9 05 "	3 36.6 "	10 08 "
			URANUS.		
Dec. 25	13 54.8	− 11 12	2 23 A. M.	7 38.8 A. M.	12 55 P. M.
Jan. 4	13 56.0	− 11 18	1 43 "	7 00.7 "	12 19 "
14	13 57.0	− 11 23	1 05 "	6 22.4 "	11 40 A. M.
			NEPTUNE.		
Dec. 25	4 12.0	+ 19 27	2 29 P. M.	9 53.5 P. M.	5 18 A. M.
Jan. 4	4 11.0	+ 19 25	1 49 "	9 13.3 "	4 38 "
14	4 10.3	+ 19 23	1 08 "	8 33.2 "	3 57 "
			THE SUN.		
Dec. 20	17 55.1	− 23 27	7 34 A. M.	11 58.0 A. M.	4 22 P. M.
25	18 17.3	− 23 24	7 36 "	12 00.5 P. M.	4 25 "
30	18 39.4	− 23 09	7 37 "	12 02.9 "	4 29 "
Jan. 4	19 01.5	− 22 42	7 37 "	12 05.2 "	4 33 "
9	19 23.4	− 22 04	7 36 "	12 07.4 "	4 39 "
14	19 45.0	− 21 16	7 34 "	12 09.4 "	4 45 "
			THE MOON.		
Dec. 20	1 47.9	+ 7 01	1 15 P. M.	7 50.1 P. M.	2 38 A. M.
25	6 20.3	+ 25 10	3 55 "	12 02.1 A. M.	8 11 "
30	10 42.5	+ 13 44	8 50 "	4 03.3 "	11 15 "
Jan. 5	14 32.7	− 11 52	2 05 A. M.	7 33.6 "	12 56 P. M.
10	19 37.6	− 24 47	7 54 "	12 18.0 P. M.	4 45 "
15	0 40.1	− 0 46	10 56 "	5 00.2 "	11 17 "

Phases and Aspects of the Moon.

			Central Time. d	h	m	
First Quarter	1890	Dec.	18	2	36	P. M.
Full Moon	"	"	25	11	57	"
Last Quarter	1891	Jan.	3	4	12	A. M.
New Moon	"	"	10	9	25	"
Apogee	1890	Dec.	30	8	00	P. M.
Perigee	1891	Jan.	11	7	48	"

Occultations Visible at Washington.

Date.	Star's Name.	Magnitude.	IMMERSION. Wash. Mean T. h m	IMMERSION. Angle f'm N. P't. °	EMERSION. Wash. Mean T. h m	EMERSION. Angle f'm N. P't. °	Duration. h m
Dec. 15	33 Capricorni	5.5	6 36	95	7 31	215	0 55
18	B.A.C. 17	6	6 50	99	7 43	188	0 53
19	26 Ceti	6	8 56	69	10 07	223	1 11
19	29 Ceti	6.5	11 36	70	12 36	235	1 00
21	38 Arietis	5.	9 01	82	10 16	215	1 15
Jan. 7	39 Ophiuchi†	5.5	17 10	167	17 40	227	0 30

† Multiple Star.

Saturn's Satellites.

[Central Time; E = eastern elongation; I = inferior conjunction; W = western elongation; S = superior conjunction.]

JAPETUS.

Dec. 28	E.	Jan. 16 11.2 A. M. I.	

TITAN.

Dec. 17 5.4 A. M. E.	Dec. 29 4.7 A. M. S.	Jan. 9 8.9 P. M. W.
21 5.1 " I.	Jan. 1 11.6 P. M. E.	14 12.5 A. M. S.
25 4.9 " W.	5 6.9 " I.	

RHEA.

Dec. 17 11.6 P. M. E.	Dec. 31 12.8 P. M. E.	Jan. 14 1.6 A. M. E.
22 12.0 M. E.	Jan. 5 12.9 A. M. E.	
27 12.5 A. M. E.	9 1.3 P. M. E.	

DIONE.

Dec. 15 8.3 A. M. E.	Dec. 26 7.2 A. M. E.	Jan. 6 5.8 A. M. E.
18 2.0 A. M. E.	29 12.8 A. M. E.	8 11.5 P. M. E.
20 7.7 P. M. E.	31 6.4 P. M. E.	11 5.1 P. M. E.
23 1.4 P. M. E.	Jan. 31 12.1 P. M. E.	14 10.8 A. M. E.

TETHYS.

Dec. 16 12.3 A. M. E.	Dec. 27 8.2 A. M. E.	Jan. 7 3.6 P. M. E.
17 9.7 P. M. E.	29 5.5 A. M. E.	9 12.9 P. M. E.
19 7.0 P. M. E.	31 2.8 A. M. E.	11 10.2 A. M. E.
21 4.3 P. M. E.	Jan. 1 11.8 P. M. E.	13 7.6 A. M. E.
23 1.6 P. M. E.	3 9.0 P. M. E.	
25 10.9 A. M. E.	5 6.3 P. M. E.	

Phenomena of Jupiter's Satellites.

	Central Time.						Central Time.			
d.	h. m.					d.	h. m.			
Dec. 17...	4 33	P. M.	IV.	Ec. Dis.		Dec. 26...	5 16	P. M.	III.	Sh. Eg.
17	5 05	"	II.	Oc. Dis.		26	5 38	"	II.	Tr. Eg.
19	4 54	"	II.	Sh. Eg.		27	4 35	"	I.	Tr. Eg.
26	4 22	"	II.	Sh. In.		27	5 24	"	I.	Sh. Eg.
26	5 01	"	I.	Oc. Dis.						

Minima of Variable Stars of the Algol Type.

Star's Name.	R.A.	Decl.	Central Times of Minima.
	h m s	° ′	
U Cephei	0 52 32	+81 17	Dec. 20, 4 A.M.; 25, 3 A.M.; 30, 3 A.M.
			Jan. 4, 3 A.M.; 9, 2 A.M.; 14, 2 A.M.
Algol	3 01 01	+40 32	Dec. 28, 2 A.M.; 30, 10 P.M.; Jan. 2, 7 P.M.
R Canis Maj.	7 14 30	−16 11	Dec. 16, midn.; 18, 3 A.M.; 19, 6 A.M.
			Dec. 26, 2 A.M.; 27, 5 A.M.; Jan. 3, 1 A.M.
			Jan. 4, 4 A.M.; 10, midn.; 12, 3 A.M.
S Cancri	8 37 39	+19 26	Dec. 25, 11 P.M.; Jan. 12, 10 P.M.
δ Libræ	14 55 06	− 8 05	Dec. 21, 5 A.M.; 28, 5 A.M.
			Jan. 4, 4 A.M.; 11, 4 A.M.
U Coronæ	15 13 43	+32 03	Dec. 23, 6 A.M.; 30, 3 A.M.

A Central Eclipse of the Sun will occur on Dec. 11 beginning at $6^h 22^m$, and ending at $11^h 43^m$ central time. It will be invisible in the United States, and only visible in Australia and the South Polar Seas.

COMET NOTES.

Ephemeris of Comet 1890 II. (*Brooks March 19*). As Bidschoff's elements given in *A. N.*, Vol. 124., p. 301, still represent the observations sufficiently well, being obtained from long intervals, I have computed the following ephemeris from them for December.

The constancy of the light at the present time is worthy of note. If we call the light on December 1 unity, the light on Dec. 31 will be 1.01, and on February 1, 1891 0.98; while on November 1, it was 1.08. As the comet is also becoming still more favorably situated for observation, with respect to the sun, it probably will be visible for some time to come:

Gr. M. T.	App. R. A.			App. Dec.		Log. r.	Log. Δ.
	h	m	s	°	′		
Dec. 1.5	13	9	49	+ 26	10	0.4620	0.4921
2.5		9	34	26	13		
3.5		9	18	26	16		
4.5		9	1	26	20		
5.5		8	42	26	23	0.4670	0.4875
6.5		8	22	26	27		
7.5		8	1	26	31		
8.5		7	38	26	36		
9.5		7	15	26	40	0.4720	0.4827
10.5		6	50	26	45		
11.5		6	24	26	50		
12.5		5	56	26	55		
13.5		5	27	27	0	0.4769	0.4775
14.5		4	57	27	5		
15.5		4	24	27	11		
16.5		3	52	27	17		
17.5		3	15	27	23	0.4818	0.4721
18.5		2	38	27	29		
19.5		1	59	27	36		
20.5		1	19	27	42		
21.5	13	0	37	27	49	0.4866	0.4666
22.5	12	59	53	27	56		
23.5		59	8	28	4		
24.5		58	20	28	11		
25.5		57	31	28	18	0.4914	0.4610
26.5		56	40	28	26		
27.5		55	47	28	34		
28.5		54	52	28	42		
29.5		53	55	28	51	0.4962	0.4554
30.5		52	56	28	59		
Dec. 31.5	12	51	54	29	8		
Feb. 1.5	11	59	26	+ 34	19	0.5353	0.4225

O. C. Wendell.

Harvard College Observatory, Oct. 11, 1890.

D'Arrest's Comet. D'Arrest's Comet has been observed by me with the 10⅛-inch refractor, which now shows it well, although I have searched for the comet several times during the summer and autumn previous to its detection by Barnard. This indicates that the comet has been growing brighter of late, although the theoretical brilliancy should have been greatest about the first of September. On November 5th I found the comet to be in R. A. $21^h\ 13^m\ 20^s, -27°\ 31'$. On Nov. 6 in R. A. $21^h\ 17^m\ 20, -27°$

28′. These places agree well with the sweeping Ephemeris published in the *A. N.* The comet is rather faint, pretty large, and with very slight central condensation. WILLIAM R. BROOKS.

Smith Observatory, Geneva, N. Y., Nov. 8th, 1890.

D'Arrest's Comet on Nov. 4 was easily seen with our 8-inch refractor. It was quite large and diffuse, having no distinct central condensation which might be taken as the point of measurement. The following ephemeris by M. Leveau indicates that it may be visible for some time yet:

Ephemeris of d'Arrest's Comet.

Paris Noon	R. A.	Decl.	Brightness.
Dec. 2	$22^h 44.9^m$	$-22° 43'$	0.22
6	22 57.0	21 44	
10	23 08.7	20 42	0.18
14	23 19.9	19 39	
18	23 30.8	18 35	0.15
22	23 41.4	17 31	
26	23 51.7	-16 26	0.12

Astr. Nach. 2959.

Comet e 1890—(Zona)—A telegram was received November 17, announcing the discovery of a bright comet by Zona at Palermo, Nov. 15 .3963 Gr. M. T. in right ascension $5^h 35^m 53.9^s$ and declination north 33° 23′ 00″. Its daily motion is westward in right ascension $4^m 48^s$, in declination north 17′.

Elements and Ephemeris of Comet e 1890. The following elements and ephemeris of Comet *e* 1860 were computed by W. W. Campbell, Observatory at Ann Arbor, Michigan, based on observations of Nov. 15, 18 and 19.

$$T = \text{July } 20.17$$
$$\omega = 317° \quad 35'$$
$$\Omega = 84 \quad 25$$
$$i = 153 \quad 02$$
$$q = 1.8229$$

Ephemeris.

	Gr. M. T.	R. A.	Decl.	L.
1890.	Nov. 21	$5^h 1^m.1$	34° 38′	0.97
	25	4 37 .2	35 2	
	29	4 14 .5	35 9	
	Dec. 3	3 52 .5	34 56	0.81

The comet discovered by Spitaler Nov. 16.643 in right ascension $5^h 27^m 16^s$, and in declination 33° 38′, is reported not found by other observers. It is undoubtedly Zona's Comet which was seen at Northfield on the evenings of Nov. 17 and 18. It was faint.

Comet f 1890—(Spitaler).—A telegram was received November 18, announcing the discovery of a faint comet by Spitaler, at Vienna, Nov. 16.6435 in right ascension $5^h 27^m 16.9^s$ and declination north 33°37′16″, Had it not been for the words, "unhideth not Zona," in the telegram, we should at once have pronounced this an observation of Zona's comet. The word *unhideth* is not found in the code.

One of these comets was observed at Northfield on the night of November 17, but the comparison star was so faint that we have been unable to identify it with any in the catalogues. The comet was very faint and difficult to observe. It was not more than 1′ in diameter, with a slight central condensation. It was seen again on the 18th, but was too faint to observe in the moonlight.

Solar Prominences for October.

DATE.	POSITION ANGLE.
1	239, 300, 346.
4	86, 120, 162, 249, 268, 275, 320.
5	85, 94, 251, 265, 274, 315, 341, 348.
8	75, 130, 264, 314, 348.
9	29, 254, 344.
10	141, 156, 165, 246, 345.
11	64, 132, 135, 140, 183.
12	64.
17	76, 83, 99, 244, 246, 300, 340.
18	66, 99, 247, 274, 325, 340.
19	66, 121, 162.
21	66, 130, 155, 170, 249.
22	66, 276, 305.
25	70, 252, 263.
26	70, 88, 252, 340.
28	68, 260.
30	65, 80, 293.
31	277.

Number of Observations, 18. Number of Prominences, 74. Mean Number of Prominences, 4.11. Highest Prominence on the 17th at P. 99. Height 96″.

Camden Observatory November 1st, 1890.

Smith Observatory Observations. The following solar observations were made with telescopes unless otherwise stated. They were taken by Charles E. Peet:

1890.	90° Mer. M. T.	Groups.	Spots.	Faculæ.	Seeing.	Remarks.
Oct. 16	12:55 p m	0	0	0	Fair.*	Gran. difficult.
17	3:30 p m	0	0	0	Good.	Gran. good.
19	3:15 p m	1	8	1	Poor.	Group too near South east limb to count the spots accurately.
20	1:00 p m	1	8	3	Bad.	
23	12:45 p m	2	24	0	Poor.	
31	9:30 a m	1	1	3	Fair.	Spot near W. limb with fac. region about.
Nov. 4	2:20 p m	0	0	0	Fair.	
11	9:45 a m	1	6	2	Fair.	Gran. fine and distinct.
12	1:30 p m	1	2	0	Good.	Gran. good.

* Projection on 20 cm. circle.

CHAS. A. BACON.

Smith Observatory, Beloit College, Nov. 15, 1890.

U. S. Naval Observatory Report for the year ending June 30, 1890, has just come to hand.

Carleton College Sunspot Observations. (Continued from page 418.)

1890.	Central Time.	Groups.	Spots.	Faculæ.	Observers.	Remarks.
Oct. 23	12:20	2	30	1 gr	C. R. W.	One large spot with finely developed umbra and penumbra—this spot is divided into three parts by light masses and streaks— 27 spots in larger group.
27		1	1		"	
Nov. 3	3:10	0	0	0	"	
4	12:35	0	0	0	"	
10	12:20	1	7	1 gr.	H. C. W.	One large spot.
12	11:00	1	7	0	"	
13	12:35	1	4	0	C. R. W.	
14	12:05	0	0	0	"	
18	9:50	0	0	3 gr.	"	
19	12:30	0	0	3 gr.	"	
20	12:35	0	0	0	"	

Planetoid (11) Parthenope. The following ephemeris is furnished by Professor Robert Luther of the Observatory at Düsseldorf, in the hope that observations may be made in this country. The magnitude of the Planetoid is 9.7 at opposition which takes place Dec. 29, 1890:

Berlin Midn. 1890.			R. A. h	m	s	Decl. °	′	″	Log. Δ	Aber'n. Time. m	s
1890	Dec.	13	6	52	7.28	+19	13	15.1	0.223459	13	43
		14		51	11.60		15	20.3	222477		51
		15		50	14.85		17	28.1	221565		49
		16		49	17.11		19	38.4	220723		47
		17		48	18.43		21	51.2	219951		46
		18		47	18.87		24	6.2	219252		44
		19		46	18.51		26	23.3	218626		43
		20		45	17.41		28	42.3	218073		42
		21		44	15.66		31	3.1	217595		41
		22		43	13.31		33	25.6	217192		41
		23		42	10.44		35	49.5	216865		40
		24		41	7.14		38	14.9	216614		39
		25		40	3.46		40	41.4	216440		39
		26		38	59.49		43	9.0	216343		39
		27		37	55.30		45	37.5	216323		39
		28		36	50.96		48	6.8	216381		39
		29		35	46.56		50	36.8	216516		39
		30		34	42.17		53	7.3	216729		40
		31		33	37.86		55	38.3	217019		40
1891	Jan.	1		32	33.73	+19	58	9.6	217386		41
		2		31	29.83	+20	0	41.1	217831		42
		3		30	26.26		3	12.7	218352		43
		4		29	23.09		5	44.2	218951		44
		5		28	20.40		8	15.7	219624		45
		6		27	18.27		10	47.1	220373		47
		7		26	16.76		13	18.2	221196		48
		8		25	15.96		15	48.9	222093		50
		9		24	15.94		18	19.2	223063		52
		10		23	16.78		20	49.1	224104		54
		11		22	18.55		23	18.5	225216		56
		12		21	21.32		25	47.3	226397	13	58
		13		20	25.14		28	15.5	227646	14	1
		14		19	30.09		30	43.0	228961		3
		15		18	36.23		33	9.8	230341		6
		16	6	17	43.62	+20	35	35.8	0.231785	14	9

New Planetoids Nos. 299 and 300. Planetoid No. 299 was discovered by Palisa, at Vienna, October 6. 4883 Gr. M. T. in R. A. 2^h 16^m 20.8^s, declination north 15° 18′ 25″, magnitude 13th. No. 300 was discovered by Palisa, November 16. 4403 in right accension 3^h 12^m 50.5^s, declination north 10° 14′ 33″. Magnitude 13th. Daily motion westward, 52^s, southward, 3′.

Wolsingham Observatory Circular No. 27. The star D. M. + 33°.470; R. A. 11^h 28^m 16^s.Decl. + 33.° 38′, (1855) Mag. 9.2, was observed on Nov. 7 as 7.5. OR. III Type. The star is probably variable.

T. E. ESPIN.

Nov. 10, 1890.

NOTES AND NEWS.

A very considerable number of subscriptions expire with this number of the MESSENGER. Our friends will oblige us by promptly writing us, if they desire its continuance for the year 1891.

The promptness with which renewals of subscriptions have been made during the last two years, has been an unexpected pleasure to us, especially in view of the increase of price during that period.

Aid for Messenger Illustrations. It will be noticed, by a circular from Professor Pickering, elsewhere given, that the MESSENGER has been very kindly and generously remembered recently, with a considerable gift of money to be used in illustrating its articles. Miss C. W. Bruce, of New York City, is the donor. We are delighted with the company in which she places the MESSENGER in her late benefaction.

James E. Keeler of Lick Observatory visited the Observatory of Carleton College, Northfield, Minn., on his way eastward a few days ago. His stay for two days was a treat for all interested in science. He gave two informal talks while in Northfield; one before the Cosmos Club in the City, on the great Lick Telescope, explaining the three lines of astronomical work it is adapted to do, viz:—Visual observation, photography and spectroscopic observation; and the other before the College Astronomy Class and a company of visitors from one of the high schools of Minneapolis. The aim of the last talk was to give something of the method of work in studying the motions of the nebulæ by the aid of the spectroscope when attached to the great equatorial at Mt. Hamilton. His presentation of this new line of work was so clear and definite that the young people readily understood it, and were enthusiastic in praise of what they heard and the manner of presenting it. He also exhibited his late drawings of the planets Jupiter and Mars, showing the fine surface markings of the former, and some features on the terminator of the latter, as revealed by the great telescope, which we have never seen or known. As specimens of drawings the

pictures were surpassingly excellent. The great red spot, the round white spots, the narrow dark bands veering around the red spot, the elongated circular openings in the great belt, with the deep red color at the bottom of them, were features of absorbing interest in Jupiter's surface markings. On the surface of Mars, the great telescope did not show, at the last opposition, as much as Schiaparelli claims to have seen at other times, and this is what might be expected, for the opposition was not a favorable one for visual study. But, in one of the pictures of Mars, was shown a very remarkable phenomenon which has been spoken of more fully in the planet notes.

Mr. Keeler's visit at Northfield was a source of pleasure and profit that will long be remembered by those who met him.

"*Father Perry Memorial.*" We have noticed, with interest, the movement that has been recently going on to secure a Memorial to the late Stephen Joseph Perry, F. R. S., the distinguished astronomer of Stonyhurst College, England. A short time ago a meeting was held under the presidency of Sir Edward Watkin, Bart., M. P., at which it was judged that such a Memorial would be sure to command general support. It has also been decided that the best mode of perpetuating "Father Perry's" name would be to continue the important astronomical work which he has begun and so well continued for years past. This work at Stonyhurst Observatory has long been hampered by the insufficiency of light supplied by the present 8-inch object glass. It is proposed, therefore, either to procure a new telescope with a 15-inch object glass, or to furnish the present equatorial stand with a 15-inch objective. This would require £2,700 for the complete telescope and house, while £700 would suffice for the objective alone. Whichever plan is carried out, the telescope and the house in which it stands will bear the name of the "Father Perry Memorial," and the work done with it will be published under that name. All persons desiring to subscribe to this worthy object are invited to send their gifts either to the "Father Perry Memorial" account at the London Joint Stock Bank, limited, Pall Mall Branch, London, S. W.; or to Arthur Chilton Thomas, Secretary and Treasurer, Marldon Chambers, 30 North John Street, Liverpool, England.

The committee in charge of this undertaking contain the names among others, of the following well known astronomers:—Robert S. Ball, Royal Astronomer, Ireland; W. H. H. Christie, Astronomer Royal, England; A. A. Common; Ralph Copeland, Royal Astronomer for Scotland; Edward S. Holden of Lick Observatory; J. Janssen, of France; J. Norman Lockyer, of England, and C. A. Young, of Princeton.

This worthy enterprise is heartily commended to the attention of the readers of the MESSENGER.

The Western Union Time Service. Comodore Dewey, chief of the equipment bureau of the Navy, makes this statement in his late report:

"A most notable feature in the affairs of the bureau in connection with the extensive telegraphic time service, which has become established and apparently indispensable commercial factor centering at the Naval Observ-

atory, has been a concerted attack upon the prevalent system by a large number of observatories located throughout the United States, the object being to break up the system in order that time, which is now furnished without cost from the Naval Observatory, may be distributed and charged for at these minor observatories as a means contributing to their maintenance. It is held by the petitioners that this system should be discontinued by the government to encourage private astronomical institutions of the United States. The subject has been strongly and earnestly presented by the directors of these institutions and detail considerations of a most interesting character enter into the discussion. A recommendation has been made, in view of the great importance of the present system to commerce throughout the country on the one hand, and of the strong case presented by the petitioners on the other hand, that the subject be referred to a commission, which shall broadly represent business and scientific interests, for examination and report."

After somewhat carefully canvassing the matter it seems to us the wise course now to take, is to have this whole matter investigated by a committee from Congress, that the country may know the truth of the unanswered charges that have been preferred.

New Naval Observatory. We notice still further in Commodore Dewey's report, that work on the new Naval Observatory has not progressed satisfactorily from a variety of causes, some natural and unavoidable, and some blameworthy. It is, however, considered probable that the new buildings will be ready for use in the early part of the fiscal year 1891-92.

The Secretary of the Navy has appointed H. E. Damrell, of New York, to be superintendent of construction at the new buildings in the place of Mr. Grant who has held the position since the work began.

Astronomy in Popular Magazines. Almost every month some of the popular magazines contain useful articles on themes from some branch of Astronomy by able scientific writers. We have often reprinted such articles, sometimes made brief extracts from others, and sometimes tried to give abstracts of still other important ones, when space at command was insufficient for fuller notice. This feature has seemed to please many of our readers judging by the favorable letters received, and we now call attention to this point, to ask our readers to do us the favor of notifying us promptly when any worthy article appears in any periodical, that *all* the readers of this magazine may have the benefit of the same.

Astronomical Papers for the American Ephemeris. The irregular intervals at which these papers have appeared leading to frequent inquiries about supposed missing parts, the following statement is issued for the information of recipients:

1. The general plan is to issue the papers in parts, so paged and arranged that they can be bound into a volume of which the paging is continuous. A title page and table of contents accompanies the concluding

part of each volume, thus enabling the completion of the volume to be recognized.

2. The catalogue of 1,098 Standard Clock and Zodiacal Stars forms Part IV of Volume I, which was completely published in 1882, but, unlike the other parts, the separate issues are bound in cloth.

3. Volumes II and III are still incomplete; the fifth part of Volume II is nearly ready, and the concluding (sixth) part of Volume III is now in the printers' hands, but is not likely to be issued before the end of the present year. I hope it will be speedily followed by the concluding part of Volume II.

4. Volume IV is issued complete, and is now in distribution.

S. NEWCOMB,
Superintendent Nautical Almanac.

Motion of the Atmosphere at High Elevation.—In the August number of the SIDEREAL MESSENGER, Professor H. A. Hazen alluded to our scanty knowledge of the direction of motion of the upper strata of our atmosphere, and it may, therefore, not be amiss to describe to your readers a personal observation made on the morning of Nov. 14th, 1867. It will be remembered that this was the time of the occurrence of the latter end of the November 14th star-shower which, on the same date of the previous year, had taken place on the eastern continent. I had observed in all its indescribable glory the great star-shower of 1833, and, inasmuch as its repetition in thirty-three years and one day had been visible in Europe instead of America, I felt quite certain that in just a year quite a shower would appear on the American side of the earth, and made arrangements for its observation. During the display I counted 896 shooting-stars. How many I lost in a cessation of twenty minutes I cannot know. Many were bright and left visible trains in their wake, but only one was seen long enough to determine accurately the direction of its motion. This exploded near the southern limit of Cancer, and disappeared near its northern boundary; its visibility lasted for, at least, twenty minutes. Its changes of form were very numerous and interesting, resembling, at times, several capital letters of the alphabet, sometimes like U, then S, but more frequently like N. Its motion was very slow exactly north, nearly over my zenith. About five minutes before its final disappearance, it centrally transited Præsepe and, while in transit, not a trace of the meteoric *debris* was visible. After gathering itself into a globular mass, it disappeared some 5° or 8° north of Præsepe. I was particularly observant of the direction of its path, having in mind Eccl. 1:6.

It is highly probable that the direction of motion of the upper strata of our atmosphere is somewhat variable, though, judging from the above phenomenon, and also from that of the trade winds, I am of the opinion that north of the equator its direction of motion is generally northward, and, but for the rotatory motion of the earth, would be undeviatingly so.

LEWIS SWIFT.

Warner Observatory, Rochester, N. Y., Nov. 12, 1890.

Aid to Astronomical Research. A circular was issued last summer announcing the gift by Miss Bruce, of six thousand dollars ($6,000) for aiding astronomical research. No restrictions were made upon its expenditure which seemed likely to limit its usefulness, and astronomers of all countries were invited to make application for portions of it, and suggestions as to the best method of using it. Eighty-four replies have been received, and with the advice of the donor the entire sum has been divided so as to aid the following undertakings:—

3. Professor W. W. Payne, Director of the Carleton College Observatory. Illustrations for the Sidereal Messenger.
6. Professor Simon Newcomb, Superintendent of the American Nautical Almanac. Discussion of contact observations of Venus during its transits in 1874 and 1882.
16. Dr. J. Plassmann, Warendorf. For printing observations of meteors and variable stars.
23. Professor H. Bruns, Treasurer of the Astronomische Gesellschaft. To the Astronomische Gesellschaft for the preparation of Tables according to Gylden's method for computing the elements of the asteroids.
27. Professor J. J. Astrand, Director of the Observatory, Bergen, Norway. Tables for solving Kepler's Problem.
29. Professor J. C. Adams, Director of the Cambridge Observatory, England. Spectroscope for the 27-inch telescope of the Cambridge Observatory.
36. Professor A. Hirsch, Secretary of the International Geodetic Association. To send an expedition to the Sandwich Islands to study the annual variation, if any, in latitude.
40. H. H. Turner, Esq., Assistant in Greenwich Observatory. Preparing tables for computing star corrections.
45. Professor Edward S. Holden, Director of the Lick Observatory. Reduction of meridian observations of Struve stars.
46. Professor Lewis Swift, Director of the Warner Observatory. Photographic apparatus for fifteen-inch telescope.
54. Professor Norman Pogson, Director of Madras Observatory. Publication of old observations of variable stars, planets, and asteroids.
57. Dr. Ludwig Struve, Astronomer at Dorpat Observatory. Reduction of observations of occultations during the lunar eclipse of Jan. 28, 1888, collected by the Pulkowa Observatory.
60. Dr. David Gill, Director of the Observatory of the Cape of Good Hope. (1) Reduction of heliometer observations of asteroids. (2) Apparatus for engraving star charts of the Southern Durchmusterung.
78. Professor A. Safarik, Prague. Photometer for measuring variable stars.
79. Professor Henry A. Rowland, Johns Hopkins University. Identification of metals in the solar spectrum.

Of the remaining replies many describe wants no less urgent than those named above. Some relate to meteorology or physics rather than to astronomy, some to work already completed, and others were received too late to be included. Two important cases may be specially mentioned. In each of them an appropriation of a part of the sum required would have been made; but in one, in our own country, an active and honored friend of the science undertakes the whole; and in the other, in France, the generous M. Bischoffsheim, already known as the founder of the great observatory at Nice, ignoring political boundaries and the comparitive selfishness of patriotism, came forward and gave the entire sum required. The same sky overarches us all. It is to be hoped that the above named, and other

foreign institutions, will obtain more important aid from neighbors when these become aware how highly the work of their scientists is appreciated in this country. The replies not enumerated above are confidential, and cannot be mentioned except by the permission of the writers. But they have placed me in possession of important information regarding the present needs of astronomers. In several cases a skillful astronomer is attached to a college which has no money for astronomical investigation. He has planned for years a research in the hope that some day he may be able to carry it out. A few hundred dollars would enable him to do this, and he offers to give his own time, taken from his hours of rest, if only he can carry out his cherished plans.

Such valuable results could be attained by the expenditure of a few thousand dollars, that no opportunity should be missed to secure this end. Fortunately, the number of persons in the United States able and willing to give liberally to aid astronomy is very large. It is hoped that some of them may be inclined to consider the case here presented. The income derived from a gift of one hundred thousand dollars would provide every year for several cases like those named above. A few thousand dollars would provide immediately for the most important of the cases now requiring aid. The results of such a gift would be very far reaching, and would be attained without delay. Correspondence is invited with those wishing to aid any department of astronomy, either in large or small sums, by direct gift or by bequest. EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY,
CAMBRIDGE, MASS., U. S. A., *November 11, 1890.*

Black Transit of Jupiter's Third Satellite.—On the evening of July 21, 1890, I observed the most intensely dark transit of a Jovian satellite that it has ever been my fortune to witness. Both satellite III and its shadow were on the face of the planet, the former showing a round disc of dense blackness, its limb sharp and well defined, while the shadow was less black in hue, being brownish in tint, and apparently not exactly circular in form, with definition of the limb somewhat less distinct. As other work demanded my attention, I did not renew the observation to see if it underwent any change of color as it neared the edge of the disc. This general phenomenon I have witnessed before, but never saw the satellite so strikingly black as on this occasion. LEWIS SWIFT.

Duplicity of Jupiter's Southern Equatorial Belt. While showing Jupiter, on August 21 last, to a college professor from Texas, using a power of 132 on the 16 inch refractor, I noted a central and exceedingly narrow division of his southern equatorial belt extending from limb to limb. Powers of 200 and 360 confirmed my suspicions, showing a dividing line of spider-thread fineness, but as bright as the planet's disc. Whether it was simply a luminous line on the belt, that I saw, or its division into two parts, I could not determine, though the separation appeared to be perfect. The line was straight, and, as I now recall it to mind, did not follow the slight sinuosities of the two edges of the belt. The observa-

tion was one of exceeding delicacy, and the phenomenon one that might easily be overlooked, but the gentleman alluded to above, as well as my son Edward, were witnesses with me of this appearance, which I had never before observed, nor do I remember to have read of anything exactly similar. LEWIS SWIFT.

Observations of Jupiter. On Sept. 7 at 9 P. M., Eastern time, Professor C. C. Hutchins, Bowdoin College, Brunswick, Maine, observed two small black spots in the southern limit of the southern great belt of Jupiter, situated a little west of the meridian and at the extremities of a semi-oval area. We have not observed them. Possibly others have seen the same objects.

Notes and News. It has been a constant regret during the past year that it has been so difficult, apparently, to secure a full, fresh table of news and notes of work from the various observatories of this country. Blanks have been sent out with prepaid return envelopes to the number of one hundred a month two or three times during the year, and but few replies in any instance have been received. This has been not only a regret but a surprise, for we know that our readers generally are more interested in this feature of the MESSENGER than in any other, and yet, so far, this important part of our work has received the least general aid. We know it is not because the hundreds of astronomers and physicists in the United States have not every week, if not every day, their attention on some interesting and useful phase of our science that would benefit somebody else if put in the proper channel, but for some reason we have failed almost wholly in this particular. Is it the fault of the MESSENGER?

Photographic Notes. A 13-inch glass prepared by the Brothers Henry for the international work of the photographic survey of the heavens, contributes a photograph of the Ring Nebula in Lyra to a receut number of *Knowledge*. This picture was taken by M. Trépied, the exposure being six hours, made on two successive nights. M. Trépied thinks that in the original negative he has evidence of at least three bright stars in the brighter parts of the ring.

M. Bischoffsheim has given 10,000 francs for a parallactic micrometer for measuring the photographs for the photographic chart of the heavens.

The Observatory for November publishes a note by David Gill on some experiments with the new Cape astro-photographic telescope. A point of interest here brought out is that for stellar photographs, after a certain period of exposure, it is quite immaterial whether the atmospheric definition is good or bad—the photographic images of stars will be equally sharp in either case."

G. M. Searle, in his lecture on "Astronomical Photography as Found in the Photographic Times," calls attention to the photographic method of determining the position of the north pole. For such determination the north polar region is photographed by a stationary telescope—the drive clock not being attached. The stars then form circular trails, having the pole for their common centre.

Velocity of Light. (Abstract of remarks of Henry M. Parkhurst, at the meeting of the Astronomical Department of the Brooklyn Institute, on Oct. 27, 1890.)

If a person riding upon a car should fire a pistol directed forward, the ball would move with the velocity produced by the powder plus the velocity of the car. Is it so with light? It has been supposed, and it would seem to be the correct view, that the motion of light is independent of the body from which it emanates; but I find it laid down in the books that the waves of the ocean, and the waves of sound, move with different velocities; the question arises whether this is also true of the waves of light, and what proof we have that it is not. I quote from standard authorities:

"But several series of waves moving with different velocities may co-exist upon the ocean."—Brande & Cox's Dictionary of Science, Article, Wave.

"It has been observed that an exceedingly loud sound travels faster than a less loud one."—Rodwell's Dictionary of Science, Article, Velocity of Sound.

The difference in the time during which a variable star is diminishing, and the time during which it is increasing, has never been accounted for. Would that be accounted for in any degree by the supposition that the light partakes of the motion of the star? Would such explanation give us an approximation to the distance of the star from the earth?

Assuming, as derived in my paper at our last meeting, that the light from Mizar takes 150 years to reach the earth, that would produce a difference of 28 days in the time of reaching us, from the opposite sides of the orbit, the period being 104 days. Tracing the light from the different points, I found that it would come to us in a symmetrical way; so that the difference just spoken of would not be at all accounted for. But I reached other peculiar results. The line would double upon itself, so that light would reach us from three different points at once, giving us the double line in the spectrum even if one of the two stars were dark. Again, where the curve doubles upon itself, from the maximum the light would suddenly drop two or three magnitudes, and after a time as suddenly rise to another maximum. Varying the assumption of distance between wide limits I could find no escape from this phenomenon. Yet along all the variable stars, we have no case where there are such changes.

Then I examined the results for Algol, in the same way. Assuming brilliancy corresponding to mass the same as of our sun, the difference of time in the arrival of light would be 1.9 days, the period being 2.8 days. I multiplied this time by 15 and divided it by 15, trying a large variety of distances between these limits. In all these cases I deduced three peculiar results, and found no evidence that they could be avoided so long as light was affected by the motion of the star. 1. The light would be arriving at all times in such a way as to cover the period of occultation; so that Algol would be brighter during the occultation than when the bright star is nearest us. 2. We should see the double lines in the spectrum, notwithstanding the darkness of the companion. 3. We should see the maximum on each side of the aphelion suddenly change to a minimum extending through the perihelion.

I consider the case of Algol as in itself a demonstration that light does not partake of the motion of the body from which it emanates.

Professor D. G. Eaton explained the variation in the velocity of ocean waves by its dependence upon the depth of the ocean, saying that in space no such cause for variation could exist.

Professor P. H. Van der Weyde explained the more rapid motion of loud sounds by supposing the vibration to have been carried more rapidly through the earth for a distance, and being then communicated to the air and taking the form of sound.

NOTE. "The velocity of the wave is accordingly proportional to the square root of the depth of the water, as the theory indicates, and it is not affected by the velocity of the impulse or the form of the body by which it is generated." Brande's Dictionary of Science. Article, Wave. This is omitted in the later edition.

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